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PROPELLANT HANDLER'S ENSEMBLE IN-SUIT NOISE MEASUREMENTS

JANUARY 1983

USAF Occupational and Environmental Health Laboratory
Aerospace Medical Division (AFSC)
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The USAF OEHL was requested by HQ Space Division (AFSC) to measure octave-band noise levels inside the new propellant handler's ensemble (PHE) for use by the Space Shuttle Activation Task Force (SATAF) at Vandenberg AFB CA. The noise levels were necessary to determine if the PHE meets the requirements of paragraph 3.1.3.6.3 of the suit specification (79K20409) and to assess the potential for possible interferences with either internal or external voice transmissions. The PHE met the specification levels in several but not all

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operating categories. Speech interference levels were also dependent on the operating category.

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PROPELLANT HANDLER'S ENSEMBLE IN-SUIT NOISE MEASUREMENTS

January 1983

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I. INTRODUCTION

The USAF Occupational and Environmental Health Laboratory (USAF OEHL) was requested by Headquarters Space Division (AFSC) to measure octave-band noise levels inside the new propellant handler's ensemble (PHE), for use by the Space Shuttle Activation Task Force (SATAF) at Vandenberg AFB, California. The noise levels were necessary to determine if the PHE meets the requirements of paragraph 3.1.3.6.3 of the suit specification (79K20409), and to assess the potential for possible interferences with either internal communications equipment or external voice transmissions.

II. BACKGROUND

A. The PHE has been developed by ILC Dover, Frederica, Delaware under contract with NASA, for use by both NASA and the Air Force in Space Shuttle operations. The problem identified at the Test Readiness Review was with noise measurement requirements of the suit specification (79K20409). Paragraph 3.1.3.6.3 states that the noise within the suit be measured using a sound level meter conforming to ANSI S1.4, Type S2A to determine if the "A-weighted," slow response level exceeds 85 dBA. More extensive data, i.e., octave-band data, were also requested by SATAF through the Space Division Bioenvironmental Engineering Office, to determine possible speech interference difficulties within the suit. Additional measurements were made to determine the noise attenuation provided by the suit. Internal noise measurements were complicated by the fact that the totally enclosed suit allowed no access for noise measuring equipment.

B. Following a presurvey to the ILC Dover facility on 7 Oct 82 by 1Lt Carolyn M. Jones, USAF OEHL/ECH, it was determined that noise measurements could be made in conjunction with the manufacturer's physiological testing program. A temporary opening provided for physiological monitors would also permit access for a microphone cable. The survey was conducted on 2 Nov 82 by 1Lt Jones.

III. EQUIPMENT

The PHE in-suit noise data were recorded on a Nagra-Kudelski Type IV SJ two-channel tape recorder with 1/2" GenRad 1962-9610 electret microphones. The octave-band data were analyzed on playback through a GenRad 1982 Precision Sound Level Meter (ANSI Type 1, which exceeds the suit specifications), and recorded on a Bruel & Kjar Type 2306 Level Recorder (see Figure 1). For the noise attenuation measurements, a GenRad 1382 Random Noise Generator was used as a source of pink noise,* which was broadcast through an Ampex Speaker/Amplifier (see Figure 2). Calibration was done with a GenRad Type 1562-A Sound Level Calibrator.

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*Pink noise: Noise whose noise-power-per-unit frequency interval is inversely proportional to frequency over a specified range.

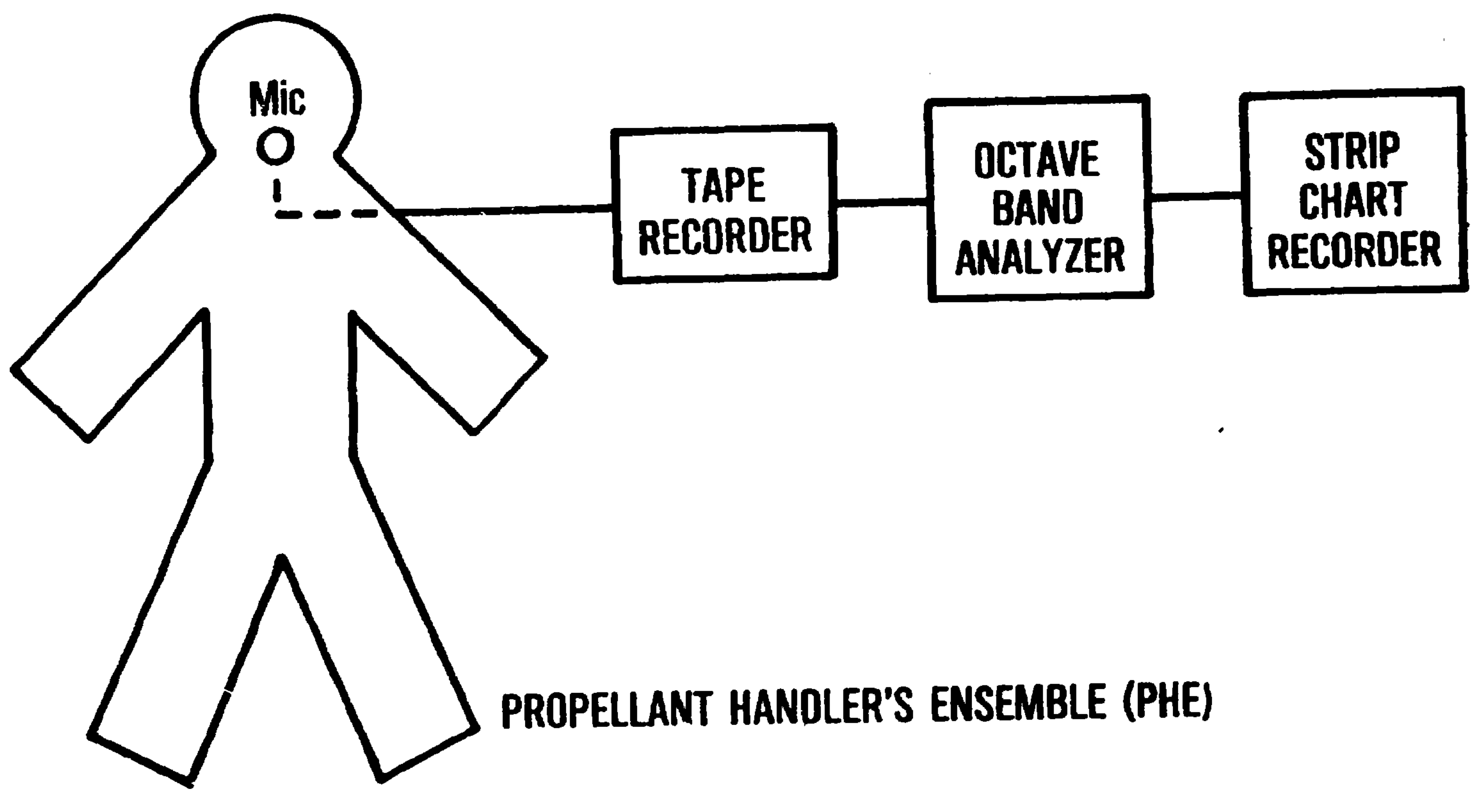

FIGURE 1. EQUIPMENT SETUP FOR IN-SUIT NOISE MEASUREMENTS

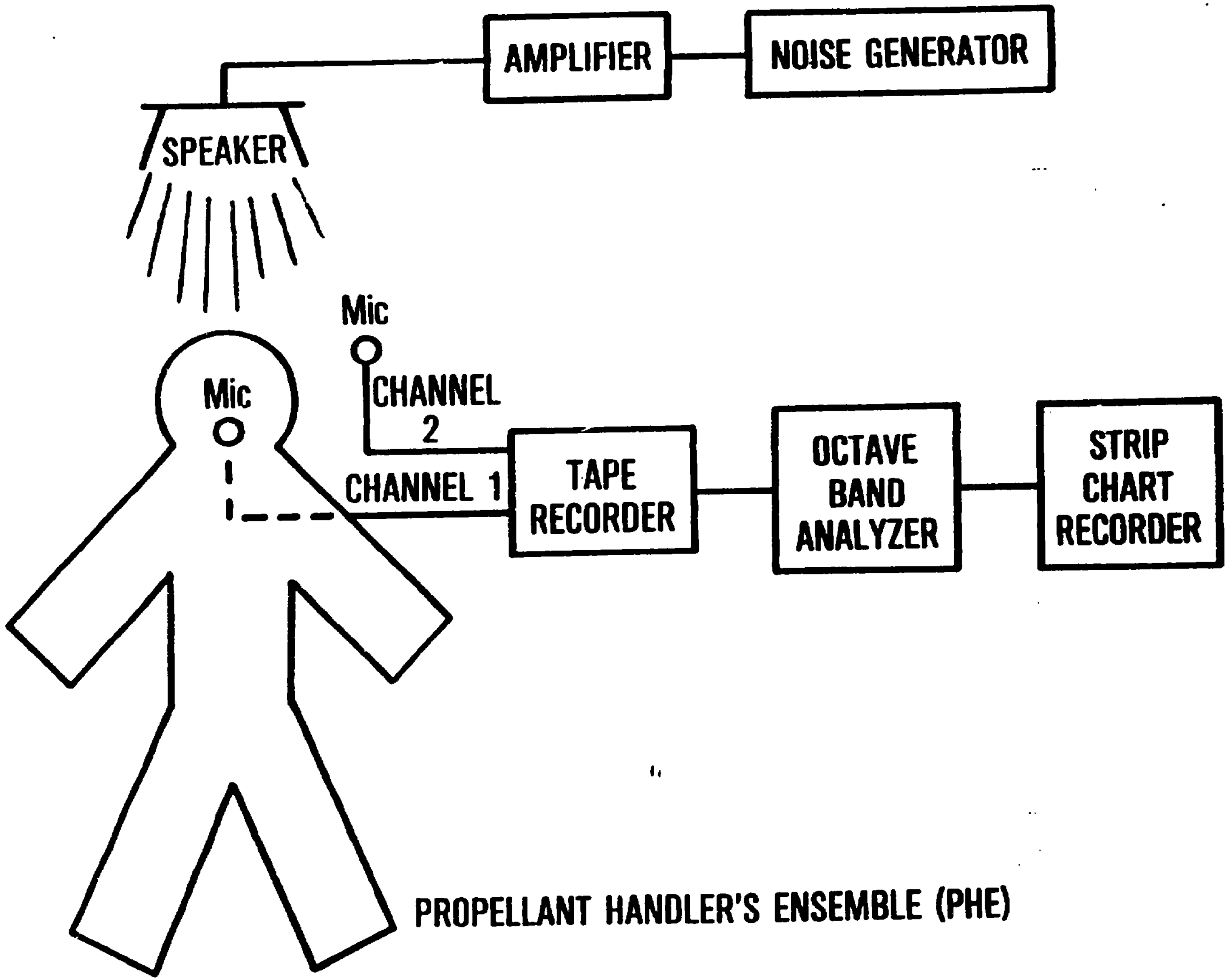

FIGURE 2. EQUIPMENT SETUP FOR SUIT NOISE ATTENUATION MEASUREMENTS

IV. PROCEDURES

A. Noise testing was done in three operational PHE airflow modes, and one nonoperational mode (see Table 1). Category I has an internal Environmental Control Unit (ECU) strapped on the back. In the normal mode, the ECU can be operated at low, medium, and high flows. The normal mode supplies air to the entire suit, recirculating a percentage of the air, and exhausting the remainder. In the event of a suit leak, a diverted mode provides clean, nonrecirculated air to the head. Category II allows the ECU to be carried in a remote case with umbilical hoses linking the ECU to the suit. This category also has both a normal and diverted mode, and low, medium, and high airflows. Category IV uses airline supplied-air through a vortex for heating or cooling, with no provision for flow settings. There is an additional emergency air supply (EAS), which was tested while the suit was in Category II, but during field use would be available in all categories. Suit attenuation measurements were made with an external noise only; i.e., all air supplies were off.

Table 1

PHE Noise Test Setup

Supply Air Mode	Category I[1]	Category II[2]	Category IV[3]	Atten. Meas.
Normal, Low ECU	X	X		
Normal, Med ECU	X	X		
Normal, High ECU	X	X		
Diverted	X	X		
Emergency Air Supply		X		
Vortex, Heating			X	
Vortex, Cooling			X	
Air Supply Off				X
Measurements				
dBA	X	X	X	
Octave Band	X	X	X	X
Flat (dB)	X	X	X	

[1]Cat I - Internal ECU
[2]Cat II - ECU in a remote case
[3]Cat IV - Airline supplied air through a vortex

B. For all three categories of in-suit noise testing, a test subject was inside the suit. The microphone cable was run through the temporary opening provided for physiological monitoring, and the microphone was mounted on the communications headset boom. Noise data were recorded in each category, and at each ECU setting to determine the interior noise and speech interference levels. The subject either sat or stood, but otherwise was motionless. Measurements were taken without the subject speaking.

C. Noise attenuation data were taken without a subject in the suit. The random noise generator was used to provide a steady state source of pink noise at least 10 dB greater than the ambient level. Microphones were mounted both inside and outside of the suit, and simultaneous data recordings were made (see Figure 2).

D. Subsequent data analysis was done on playback by sending the recorded noise signal through a sound level meter capable of octave-band analysis. Noise levels per octave band were then recorded on a strip chart recorder. This system for data analysis was adequate because the ECU noise was steady state.

V. RESULTS

A. Table 2 summarizes the octave-band, A-weighted, and flat noise levels in each test category. Table 2 also lists the 4-Band Speech Interference Levels (dB SIL)* which are related to specific levels of difficulty in speech communications (per AFR 161-35). Table 3 presents the octave-band noise levels at the ear when a "typical" communications headset with ear muffs is worn. Table 4 summarizes simultaneous internal and external octave-band noise levels to determine the attenuation provided by the PHE.

B. From the data in Table 2 it is evident that, in the normal operating mode for Categories I and II, the PHE interior A-weighted noise levels approach, but do not exceed the specified 85 dBA. In Category I the noise level exceeds the standard when in the diverted mode, which does not represent normal operation. However, in Category IV the A-weighted levels exceed 85 dBA by 11 dB for the heating mode and by 7 dB for the cooling mode. Specification 79K20409 does not state which configuration(s) must meet the standard; compliance with the design criteria is to be determined by the contracting office. When the headset attenuation data are applied to the internal ECU noise levels, the level at the individual's ear is well below 85 dBA in all modes (see Table 3).

C. The degree of speech interference is low in Categories I and II and moderate in Category IV. Using the 4-Band Speech Interference Levels and Figure 3 (AFR 161-35, Figure 1) it is clear that for Categories I and II internal communications are possible with a normal voice level. The individual will also be wearing a communications headset with a dB-cancelling microphone to further enhance speech communications. In Category IV, a "raised" to "very loud" voice may be necessary, again, the noise cancelling microphone will assist with voice pickup. At the time of this survey the headset was not functional. If problems arise during field use, testing with the communications headset may be necessary.

D. The ability of the suit wearer to hear a voice through the suit (i.e., not over the communications system) will depend on the distance from the speaker and the ECU category. In Categories I and II, normal external voice transmissions should be adequate up to six feet between speaker and listener.

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*4-Band Speech Interference Level is the arithmetic average of the 500, 1000, 2000, and 4000 Hz octave-bands.

Ta le 2

Octave-Band, A-weighted, Flat, and 4-Band Speech Interference Levels for the Propellant Handler's Ensemble (dB)

Operating Mode		31.5	63	125	250	500	1K	2K	4K	8K	16K	dBA	Flat	Speech Interference Level
Cat I	Normal, Low ECU	74	70	70	70	70	83	73	65	61	<50	83	83	73
	Med ECU	72	72	72	72	72	84	75	67	63	<50	84	84	75
	High ECU	72	70	72	72	72	83	72	67	63	<50	83	84	74
	Diverted Mode	62	63	63	67	71	88	73	66	60	52	88	89	75
Cat II	Normal, Low ECU	61	66	70	72	70	71	65	59	51	<40	73	78	66
	Med ECU	75	73	73	71	67	71	69	64	55	<50	75	79	68
	High ECU	64	65	71	73	74	74	71	67	58	<50	78	81	72
	Diverted Mode	79	78	76	73	69	72	71	67	58	<50	78	83	70
	EAS	60	61	62	64	60	66	73	79	74	65	82	82	70
Cat IV	Max Air, Heating	69	73	83	83	85	84	86	90	90	74	96	95	86
	Cooling	65	66	74	75	77	82	83	89	83	65	92	92	83
Room Ambient		60	59	58	57	54	50	46	44	42	36	58		

In Category IV external voice transmissions will be difficult. In all categories the attenuation from the communications headset provides the greatest interference to external voice transmissions.

Table 3

Octave-Band Noise Levels at the Ear with Communications Headsets (dB)

	Frequency (Hz) 125	250	500	1K	2K	4K	8K
Ground Communications Headset Attenuation[1]	-14	-23	-36	-22	-24	-28	-25
Operating Mode	dB Level at Ear with Headset						
Cat I Normal Mode							
Low ECU	56	47	34	61	49	37	36
Med ECU	58	49	36	62	51	39	38
High ECU	58	49	36	61	48	39	38
Cat II Normal Mode							
Low ECU	56	49	34	49	41	31	26
Med ECU	59.	48	31	49	45	36	30
High ECU	57	50	38	52	47	39	33
Cat IV Heating Mode	69	60	49	62	62	62	65
Cooling Mode	60	52	41	60	59	61	58

[1]Reference: AFR 161-35, Table 4

Table 4

External and Internal Noise Levels (dB) from Pink Noise Source and Attenuation Loss

	31.5	63	125	250	500	1K	2K	4K	8K	16K
External	64	65	74	78	77	72	72	66	63	55
Internal	64	65	75	79	77	66	66	55	<50	<50
External-Internal (Attenuation)	0	0	-1	-1	0	6	6	11	>13	>5

E. Attenuation measurements for the PHE (see Table 4) show that the attenuation through the suit is nonexistent in the low frequencies, and minimal in the mid- to high-frequency ranges.

VI. CONCLUSIONS

The following conclusions can be drawn from this survey:

A. When the PHE is operated in Categories I and II, in the normal mode, the interior noise levels do not exceed 85 dBA.

B. When the PHE is operated in Category I, diverted mode, or in Category IV, the interior noise levels exceed 85 dBA.

C. In Categories I and II, speech interference from ECU noise is minimal.

D. In Category IV, speech interference may occur from the interior suit noise levels. Testing with a functional communications headset may be necessary if problems are encountered.

E. A PHE wearer should be able to hear a speaker talking through the suit, when both are close to each other, and the ECU in Categories I or II. In Category IV, external voice transmissions may be difficult; however, communications through the headset should be adequate.

F. Noise attenuation through the PHE is minimal.

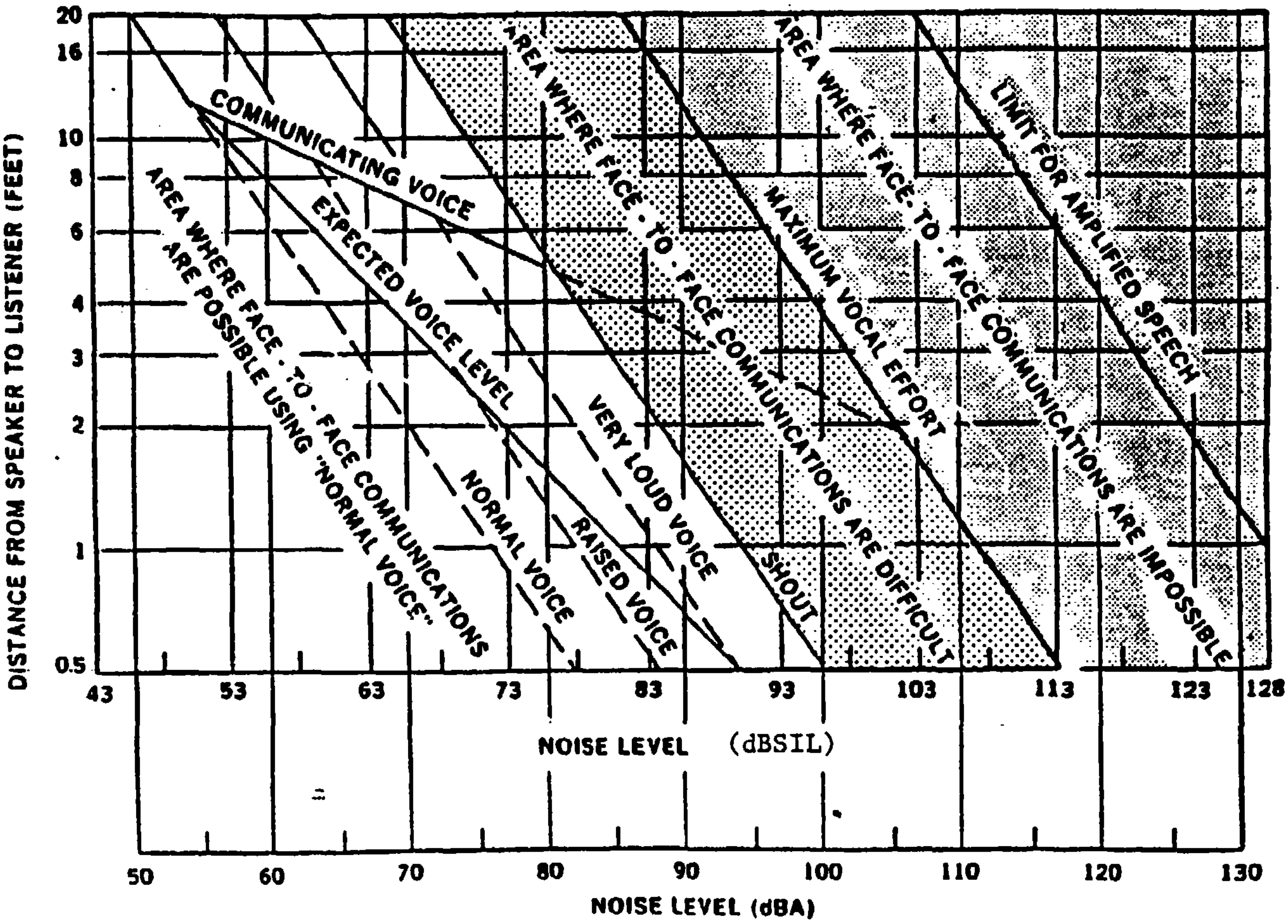

FIGURE 3. EFFECTIVENESS OF VOICE COMMUNICATION (AFR 161-35)